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Transmitted herewith for filing is the Patent Application of:

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William G. Pope of Somers, New York

For: SYSTEM AND METHOD TO IMPROVE SERVICE
IN A GROUP OF SERVERS

Enclosed are:

X 28 Pages of Specification.

X 11 Sheets of Informal Drawings.

X Declaration and Power of Attorney is attached to the application.

X Assignment and Assignment Cover Sheet.

The filing fee has been calculated as shown below:

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___ Any patent application processing fees under 35 CFR 1.17.

Respectfully submitted,

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Enclosures

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SYSTEM AND METHOD TO IMPROVE SERVICE IN A GROUP OF SERVERS

Field of the Invention

The invention relates generally to the field of computer systems and more particularly to a system and method for optimizing computer resource usage across a plurality of computer systems.

Background of the Invention

In the capacity planning process, system parameters, desired service levels, and workload predictions are used to determine when the resources of a computer system will be exceeded and are used to assist in identifying cost-effective remedies to resource shortfalls. "Capacity Planning and Performance Modeling: From Mainframes to Client-Server Systems", by Daniel A. Menasce, Virgilio A. Almeida, and Larry W. Dowdy (Prentice Hall, Englewood Cliffs, New Jersey, 1994) discloses approaches to both the predicting and rectifying of computer resource challenges.

Capacity planning for a set of heterogeneous computer systems presents several problems, as set forth below. As a first challenge, it must be recognized that workloads use multiple resources. Therefore, the effect of workload assignment

is not readily predicted or quantified. Second, workload typically grows, and the rate of growth may differ between resources. Third, different computer systems may have different resources, and different resource capacities. These problems can make it difficult to determine how long available resources will last, which computer systems are most at risk for exceeding their resources, how to reallocate resources to alleviate shortages, and how the computer systems will be affected by such reallocations.

Dan Asit and Dinkar Sitaram, in U.S. Patent No. 5,530,557, entitled "Online Placement of Video Files Determined by a Function of the Bandwidth to Space Ratio of each of the Storage Devices in a Server Environment", (June 25, 1996) teach one solution for maximizing storage utilization for the placement of videos on storage devices taking into account the expected demand for the video. Asit, et al use the bandwidth space ratio (BSR) to place videos on disks. The BSR of a disk is its bandwidth divided by space. The BSR of a video is the expected demand for the video divided by the space required to store it. Demand may be forecast based on historical usage data and, in their invention, a Video Placement Manager places the videos on the disks to match the BSR of the videos with the BSR of the disk.

Additional references which have sought to predict and manage storage capacity include an article and related patent

application of W. G. Pope and Lily Mummert. The article entitled "The Use of Life Expectancy to Manage Notes Domino E-Mail Storage", Proceedings of the Computer Measurement Group, CMG '99, December 1999, and the patent application, Serial No. 09/457,467 entitled "System and Method for Providing Property Histories of Objects and Collections For Determining Device Capacity Based Thereon", which was filed on December 8, 1999, propose a method for projecting device capacity by past history of access to and usage of the relevant information for a single computer system.

In general, the amount of workload on a computing system grows over time. Eventually, workload exceeds the system's capacity causing either unscheduled outages or severe performance degradation which results in increased administrative costs and reduced customer satisfaction. When the server is a member of a group of servers where workload can be moved to some other server in the group, it is desirable to avoid these problems with planned action, as will be addressed by the present invention.

The date when a server's workload exceeds its capacity is called its expiration date. An expiration date is established using the aforementioned methods like life expectancy or capacity space. To provide a quality service, it is necessary to upgrade or offload the server before its expiration date. Usually, there are certain key dates when major changes can be made to a server with minor impact to service. These dates are conventionally associated with holidays, whereby service impact is reduced if

servers are upgraded on a key date that precedes the expiration date.

Other resources, such as administrative personnel, are normally in limited supply. This constraint bounds the number of server upgrades that can be performed on any given key date. Thus, it is necessary to distribute the expiration dates of servers to fit within the bounds dictated by these other resources. A system's expiration date can be adjusted by adding or removing workload.

What is needed is a system and method which analyzes the combined expiration dates of a group of systems and adjusts the location of workload to align the expiration dates of systems in the group with key dates in order to fit within the bounds dictated by external resources.

What is additionally needed is to provide a system and method for analyzing the impact of a single workload unit on the capacity of a system.

Another objective of the present invention is to utilize workload unit impact measurements to improve the life expectancies of as many of the processing systems in a processing environment as possible.

Summary of the Invention

The foregoing and other objectives are realized by the present system and method which utilizes a single measure for the workload unit. This measure is called the impact which is measured in time (usually days) and represents the effect of the workload unit on the expiration date of the system. The method is more robust in that the measure of a workload unit is calculated in relation to a specific processing system and the other workload assigned to the system, other than the workload unit in question. This measurement technique is effective and relevant for an iterative planning process that examines the movement of workload units to achieve a desired configuration of expiration dates within a processing environment.

The system and method of the present invention provide for evaluating workload units in a computer system whereby each workload unit is assigned an impact number representing the number of days that the expiration date of a computer system would be changed if the workload unit were to be added or removed from the system with all other workload units remaining the same. The impact number for a given workload unit may differ depending upon the system to which it is assigned. The inventive system and method simplify the task of combining multidimensional workload measures and incorporate the interaction with other workload units in the system by assessing the impact on both a

donor and a recipient computer systems' expiration dates. Thus, the invention provides a more robust way to measure the effect of moving workload units between systems to result in a better allocation of work amongst computer systems in a processing environment.

Brief Description of the Drawings

The invention will now be described in greater detail with specific reference to the appended drawings wherein:

Fig. 1 illustrates a processing environment for implementing the present invention;

Fig. 2 provides a timeline and server placement example;

Fig. 3 illustrate a graph associating computer servers with key planning dates;

Fig. 4 provides a process flow diagram depicting the highest level of the methods of this invention;

Fig. 5 provides a process flow diagram depicting the assignment of targets to list L;

Fig. 6 provides a process flow diagram depicting the processing of the From list;

Fig. 7 provides a process flow diagram depicting the process flow for extending the expiration date of a computing system;

Fig. 8 provides a process flow diagram for calculating the impact of each workload unit on a computing system's expiration date;

Fig. 9 provides a process flow diagram for selecting the best server in the To list;

Fig. 10 provides a process flow diagram for moving the workload unit from the From to the To computing system; and

Fig. 11 provides a process flow diagram depicting the recalculation of the expiration date for systems s and b in accordance with the foregoing.

Detailed Description of the Invention

For the ensuing description of the invention, the following terms will be used:

An *administrative processor* is a computer system with the capability to execute computer software and programs. Here the term administrative processor refers to hardware including at least a central processing unit along with the memory and input/output interfaces for transferring digital data between the inside of the system and the outside world and the operating and support software, i.e. operating system and support subsystems that allow the hardware devices to be used. The term administrative processor is not meant to include any devices for the permanent storage of data. The administrative processor may

be part of a separate processing system (as shown in Fig. 1) or may be a component of one of the processing systems in the processing environment for which the workload analysis is to be conducted. More than one administrative processor can serve a single processing environment.

A *repository* is a means for storing structured data external to the administrative processor. Data in the repository is saved and accessed in a storage subsystem but is also supported by software, such as relational database software, that provides access to the structure of the data. Database software is not essential for a repository as the content of the repository can be stored in simpler storage objects, such as a flat file.

A *processing system* is a computing system that includes all the hardware and software needed to execute computer programs. This includes the central processing unit (CPU) or multiple CPUs, memory, storage and network connectivity as well as the operating system, application software and procedures for managing work on the system.

Workload is the set of identifiable tasks that execute in the processing system and utilize or consume the resources of the system.

A *workload unit* is a subset of the workload that can be associated with some external identifier (e.g., the collection of all tasks executed by an employee user.) Workload units are a collection point for keeping historical records about resource

consumption and act as a means to allocate workload to a specific processing system. Workload units may execute anywhere in the processing environment, subject only to resource constraints.

A *container* is a generalized term that represents an identifiable and limited part of a resource that has a limit, or *capacity*. A storage container might be a disk partition or an entire physical device, limited by its size. A processing container might be a CPU, a set of CPUs, or a specific type of server. The limit might be some number of instructions or transactions per unit time. A network container could be an interface, or the network itself, and the limit could be the bandwidth. In any case, the resource has a limit (capacity) which cannot be exceeded without external intervention. Attempts to exceed the capacity of a container will result in degraded performance or failure.

A *processing environment* is a collection of processing systems that are capable of executing the workload for any of the workload units executing within the environment. The administrative processor has access to the storage subsystem(s) in its storage environment. Through the storage subsystems, it can identify all of the containers in each subsystem, the limits of those containers, the identity of all of the objects in each container, and the resource usage of each object.

A *threshold* is an artificial limit on utilization that is used by the capacity planning process to prioritize containers

that need action. When the projected utilization of a container reaches the threshold, the container is selected to be managed, and action will be taken to prevent or alleviate the resource shortage in that container.

Capacity management is the process of projecting and managing the allocation of workload unit to processing systems within a processing environment so that capacity limits are not exceeded within a planning horizon. Capacity management is depicted by three high level steps: (1) collecting information about the processing environment, (2) projecting the state of the processing environment at some time in the future; and (3) defining actions to prevent the over commitment of any processing system.

The *life expectancy* of a processing system is the period of time from the last measurement of the system until the increase in resource consumption is expected to exceed the capacity of any one of the system's resources. If the change in resource consumption over time is non-positive and the system is operating below its capacity limit, then the life expectancy of the system is considered infinite. If the resource consumption exhibits positive growth for any system resource dimension, the life expectancy of the system is finite.

A system's *expiration date* is the date when the server workload is expected to exceed its capacity because of growth in workload. An expiration date is calculated using life expectancy

as set forth in co-pending patent application Serial No. 09/457,467 entitled "System and Method for Providing Property Histories of Objects and Collections For Determining Device Capacity Based Thereon", which was filed on December 8, 1999, or capacity space as set forth in co-pending patent application Serial No. _____, entitled "System and Method for Analyzing Capacity in a Plurality of Processing Systems, which was filed on October 17, 2000, or some comparable method (see also: Daniel A. Menasce, Virgilio A. Almeida, and Larry W. Dowdy. "Capacity Planning and Performance Modeling: From Mainframes to Client-Server Systems", Prentice Hall, Englewood Cliffs, New Jersey, 1994 and Bucky Pope and Lily Mummert, "The Use of Life Expectancy to Manage Notes Domino E-Mail Storage", Proceedings of the Computer Measurement Group, CMG '99, December 1999). For the purposes of the present invention, the use of the terms "expiration date", "life expectancy", and "capacity space" will be understood to be mutually-interchangable alternatives representing measurements of a processing system's capacity.

The *impact* of a workload unit is the effect on the system's expiration date that results from either adding the workload unit to the system or removing it. The impact is calculated by taking the difference between the expiration date before and after the workload change.

The system where this invention would apply is represented in Figure 1 comprising a processing environment having an

administrative processor 101 is adapted to implement the inventive process. The administrative processor 101 has access to a data repository 102, such as a relational database, where the data can be saved and from which data can be retrieved. The administrative processor also has access to configuration data about properties of the processing environment 100, comprising processing systems 104a and 104b, and about workload needs and workload usage history data relating to the workload units 105a and 105b that are part of the processing environment.

The objects of interest for this invention are processing systems 104a and 104b that manage workload units. An example of work which is to be divided up into workload units to be managed by the respective processing systems is a sort program run on behalf of a computer user. Each workload unit has a unique identifier, within the processing environment. Workload units consume resources of the processing systems. The resources consumed by a workload unit are recorded by the processing system and the record of this consumption is transferred as the workload usage history to the administrative processor 101 and stored in the repository 102. Each resource has its own unit of measure. These consumption records are identified by the name of the workload unit and the time period of the consumption.

The administrative processor makes use of three inputs: a table of key planning dates, the set of tables of workload units for each processing system and the table of processing systems in

the installation. With the relevant information, the administrative processor associates each processing system in the processing environment with a key planning date on the planning horizon. An objective of the invention is to ensure that each processing system's expiration date falls after a specified key planning date. If the administrative processor finds that a system will run out of capacity before its assigned key planning date, it will perform an analysis and select workload units to move to another system. Then, it will search the other systems in the environment to determine where to place the workload unit. In general, removing workload from a system results in a later expiration date while adding workload to a system typically results in an earlier expiration date.

The analysis of the system capacities and selection of workload units for transfer continue until the objective is met whereby all systems' expiration dates are later than their key planning dates. The result of the analysis is a plan to move workload units between systems in the environment. If an assignment of workload that satisfies the planning dates is not possible, a partial plan can be created to improve the state of the system even though it fails to meet the ultimate planning objective.

Figure 2 illustrates the inventive methodology. The expiration date for system s1 places it before key planning date d1. By removing workload from s1, the system's expiration date

is extended as represented by arrow 202. The process continues to remove workload until the server's expiration date falls after the key planning date. Workload removed from one system must, of course, be moved to another system in the group, depicted in Figure 2 as arrow 201. Moving workload onto a server shifts that server's expiration date to the left on a timeline. Figure 2 illustrates this with system s2. Adding workload to s2 moves its expiration date to the left as indicated by arrow 203.

Let Table D be a date table with i entries, one for each date in the planning horizon. Each date entry Di is a tuple of two values {di,ci} where di is the planning date and ci is a count representing the number of systems that must expire after that date. The administrative processor assumes that D has been created by some external means. Usually planning dates are chosen in such a way to minimize impact on service, such as holidays. Additionally, it must be noted that the number of systems that may be reconfigured on a given date may be affected by other resources, such as amount of available administrative personnel.

Let Table L be the table of j systems to be managed. Each entry Lj is a tuple of two values {sj,ej}, where sj is the name of the system j and ej is the expiration date for system j, calculated using life expectancy, capacity space, or some similar methodology. The number of servers j must equal the sum of the counts (ci) found in date table D.

Let Table W with k entries represent all of the workload units on the group of systems. Each entry Wk consists of a tuple of the following values {uk, sk} where uk is the identifier of the workload and sk is the name of the system that most recently served the workload.

The invention works with date deltas as depicted in Figure 3. Figure 3 shows seven systems indicated by the circles 301-307 marked s1 to s7. The planning horizon is indicated by a timeline marked t1 to tn. Three key planning dates are indicated: d1, d2, and d3. The seven systems are divided into three subsets, one subset for each key planning date. The systems s1-s7 have been ordered in expiration date sequence and positioned above the planning horizon in line by their expiration date. Each key planning date has a number of systems assigned to it as depicted by the number in parentheses following the date: two for d1, three for d2, and two for d3. Subset 1 consisting of systems s1 and s2 are assigned to d1. One system, s1, expires before d1 and has a negative date delta as shown at 311 by Δ_1. The second system, s2, has a positive delta date, Δ_2, shown at 312, because the expiration data of the system fall after the key planning date.

The invention creates an output referred to as the move table M. Let Table M have l entries. Each move entry Ml is composed of three entries {ul, fl, tl} where ul is the designator for workload unit l, fl is the current location of the workload

("From" system) , and tl is the next location of the workload ("To" system).

Figures 4-11 depict one implementation of the invention, based on a greedy algorithm. Figure 4 provides a process flow diagram depicting the highest level of the methods of this invention. The first step 401 is to retrieve the list of systems L from the repository. The list is sorted in ascending date sequence by the expiration date (e) of each system in the list. Step 402 assigns each system to a key planning date as is explained in Figure 5. Next, in step 403, the From list F, the To list T and the Move list M are initialized with empty list structures. In step 404, the first system in list L is assigned as server 1. Step 405 calculates the Δ for system 1 by subtracting the key planning date from the system's expiration date. Step 406 next determines if the server needs to have workload removed. If the system will expire before the key planning date, that is the Δ is negative, then action must be taken to remove workload. If, in step 406, the determination is made that the system will expire before its planning date, the system is added to the From list F in step 407. If the system will not expire before its key planning date, it is a candidate to receive workload and is added to the To list T (in step 408). Step 409 determines if all systems in list L have been allotted to either the From list or the To list. If there are more systems to process, step 410 picks the next system in the list,

otherwise processing continues in step 411 as described starting with Figure 6.

Figure 5 describes the procedure for assigning key planning dates to every system in list L. First, in step 501, the date Table D is retrieved from the repository and the key planning dates are sorted in ascending date sequence. In step 502, the date in the first tuple in Table D is assigned to d and the count value is set for c. The first system in List L is assigned as l in step 503. In step 504, planning date d is assigned to l. Step 505 tests to determine if all systems have been assigned a date and, if so, the process returns the completed list L. If there are more systems in List L, step 506 first decrements the count c to indicate that date d was assigned to l. If there are more systems to be assigned to the planning date d (i.e. c > 0 in step 507), then the processing proceeds to step 508 where the next system is assigned as l, otherwise step 509 picks the next date in Table D, and processing continues with step 508.

Figure 6 describes the procedure for processing of the From list F. The From list comprises a list of the systems that need workload removed. Step 601 prioritizes the list in ascending expiration date sequence since the systems that expire the soonest must be addressed first, as there is less time to make changes to the installation. Step 602 prioritizes the To list of systems in descending expiration date sequence so that workload is moved to the server that is the farthest to the right on the

planning horizon time line. This procedure is complete when either the From list or the To list is empty, as indicated by the decision boxes of steps 603 and 604. If the From list has entries, there are some systems that will expire before their target date and for which workload must be removed. When there are systems in the To list, there are potential candidates to receive the workload. Step 605 assigns the next system in the From list to s and step 606 performs the process of finding the right workload unit to remove and the right system to receive the workload unit, as further detailed with reference to Fig. 7.

Figure 7 details the process for determining how to extend the expiration date of a system. Step 701 retrieves a table of the workload that currently uses system s. Step 702 is a procedure (further detailed in Fig. 8) that determines the impact of removing each workload unit for the system. The workload list is sorted in descending order by impact in step 703 and the workload at the top of the list is selected in step 704. Step 705 tests to determine if the workload list is empty and if it is, the procedure is complete because there is no more work that is available to move. Step 706 is a procedure that finds the best server to receive the workload unit u. It may be that no system is capable of receiving workload unit u (as tested in step 707) in which case the next workload unit is selected in step 708 and the procedure returns to the test in step 705. If there is a system to receive unit u, the workload is moved in procedure 709

(Figure 10) and the expiration date for system s is recalculated in step 710. Since the expiration dates of systems in the From and To list have been changed by the movement of workload unit u, the two lists are resequenced before the procedure exits.

Figure 8 details the process for calculating the impact of each workload unit on a system. The unit of measure for impact is time, usually recorded in days. First, in step 801, the list of workload units assigned to the system in question is retrieved from the repository. Next, in step 802, the first workload unit is selected. It is here to be noted that there need be no particular order to the workload list for this procedure. The selected workload unit is temporarily removed from the list in step 804, and a new expiration date is calculated using the remainder of the list. The difference between this new expiration date and the original expiration date is assigned to the selected workload unit at step 805 as its impact, and the workload unit is returned to the list. If all workload units have been processed, the procedure completes. If not all workload units have been processed, the system proceeds to the next workload unit to be processed at step 807. When all iterations are completed, each workload unit will have been assigned an impact number that represents the change in expiration date if that workload unit, only, is removed.

Figure 9 describes how the system is selected to receive a workload unit. First, the list of To systems must be ordered in

priority sequence. Step 901 sorts the list of To systems in descending expiration date sequence. The use of expiration date is one way of prioritizing the list, although other prioritizing functions could be substituted at this point. The top system on the list is selected as the next candidate at step 902, as long as there are candidate To systems on the To list, as determined at step 903. In step 904, the list of workload units for that system is retrieved from the repository. The additional workload unit is added to the list at step 905 and the expiration date is recomputed in step 906. Step 907 compares the new expiration date with the selected systems key planning target date. If the expiration date still falls beyond the key planning data on the planning time line, the procedure is complete and the selected system is returned as the best candidate at step 910. If the addition of this workload causes the system expiration date to fall short of the key planning date, as determined at step 907, the method proceeds to step 908 where the next system on the list is selected as a candidate. The process continues until either an appropriate system is found (step 907) or until all systems have been examined and none have qualified to receive the workload, as determined at step 903.

When the process successfully finds a workload unit that can be moved, is creates an entry in the move table and updates the workload lists for the From and To systems. Fig. 10 illustrates the updating process. Step 1001 retrieves the workload unit list

from the repository for the From system and step 1003 retrieves the workload unit list for the To system. The workload unit is removed from the From system workload list and the list is returned to the repository at step 1002. The unit is added to the To systems workload unit list and that list is returned to the repository at 1004. Finally, the tuple representing the name of the workload unit, the From and To system is added to the Move table in step 1005.

Figure 11 is the last process in this method as it recalculates the expiration dates for the From and To systems. At step 1101 the workload unit list is retrieved from the repository for the To system and the expiration date of the To system is recalculated. The updated tuple is saved with the system identifier and the expiration date to the To list at step 1103. For the From server, the workload list is first retrieved from the repository (step 1104) and the expiration date is recalculated at 1105. The procedure tests for the possibility that the expiration date now falls after the key planning target date as determined at step 1106. If this is the case, the entry is moved to the To list at 1107, otherwise it remains of the From list.

While the invention has been described with reference to an illustrated system and several preferred process flow embodiments, it will be apparent to one having skill in the relevant art that modifications can be made without departing

from the spirit and scope of the invention as set forth in the appended claims.

CLAIMS

Having thus described our invention, what we claim is:

1. A method for evaluating workload across a processing environment having a plurality of computer systems each having a plurality of assigned workload units comprising the steps of:

assigning a plurality of impact values, one to each workload unit assigned for each of the plurality of computing systems, said assigning comprising determining the change in system expiration date should each one of said plurality of workload units be removed from the system; and

assessing the workload based on said impact values.

2. The method of Claim 1 wherein the change in system expiration date is determined based on system life expectancy.

3. The method of Claim 1 wherein the change in system expiration date is determined based on capacity space.

4. The method of Claim 1 further comprising sorting said workload units based on said impact values into a sorted impact list.

5. The method of Claim 1 further comprising altering the workload in the processing environment to change the expiration dates of at least two of said plurality of computer systems.

6. The method of Claim 1 further comprising comparing the expiration date of each of said plurality of computing systems to at least one target planning date for servicing each of said plurality of computing systems.

7. The method of Claim 6 further comprising altering the workload in the processing environment to change the expiration date relative to the target planning date for at least two of said plurality of computer systems.

8. The method of Claim 6 further comprising the steps of:

creating a From list of computer systems for which the expiration date precedes the at least one planning date;

creating a To list of computer systems for which the expiration date is later than said at least one planning date; and

reassigning workload units from computer systems on said From list to computer systems on said To list based on said impact values.

9. The method of Claim 8 further comprising calculating new expiration dates for computer systems on said From and said To lists after said reassigning.

10. Apparatus for evaluating workload across a processing environment having a plurality of computer systems each having a plurality of assigned workload units comprising:

an administrative processor comprising:

an impact value component for assigning a plurality of impact values, one to each workload unit assigned to each of the plurality of computing systems, by determining the change in system expiration date should each one of said plurality of workload units be removed from the system; and

a processing component for assessing the workload based on said impact values.

11. The apparatus of Claim 10 further comprising at least one storage location accessible by the administrative processor for storing data relating to said plurality of computer systems.

12. A program storage device readable by machine tangibly embodying a program of instructions executable by the machine to perform method steps for evaluating workload across a processing environment having a plurality of computer systems each having a

plurality of assigned workload units, said method comprising the steps of:

assigning a plurality of impact values, one to each workload unit assigned for each of the plurality of computing systems, by determining the change in system expiration date if each of said plurality of workload units is removed from the system; and

assessing the workload based on said impact values.

13. The device of Claim 12 wherein the method further comprises sorting said workload units based on said impact values into a sorted impact list.

14. The device of Claim 12 wherein the method further comprises altering the workload in the processing environment to change the expiration dates of at least two of said plurality of computer systems.

15. The device of Claim 12 wherein the method further comprises comparing the expiration date of each of said plurality of computing systems to at least one target planning date for servicing each of said plurality of computing systems.

16. The device of Claim 15 wherein the method further comprises altering the workload in the processing environment to change the

expiration date relative to the target planning date for at least two of said plurality of computer systems.

17. The device of Claim 16 wherein the method further comprises the steps of:

creating a From list of computer systems for which the expiration date precedes the at least one planning date;

creating a To list of computer systems for which the expiration date is later than said at least one planning date; and

reassigning workload units from computer systems on said From list to computer systems on said To list based on said impact values.

18. The device of Claim 17 wherein the method further comprises calculating new expiration dates for computer systems on said From and said To lists after said reassigning.

19. The device of Claim 12 wherein the change in system expiration date is determined based on system life expectancy.

20. The device of Claim 12 wherein the change in system expiration date is determined based on capacity space.

SYSTEM AND METHOD TO IMPROVE SERVICE IN A GROUP OF SERVERS

ABSTRACT

A system and method for evaluating workload units in a computer system whereby each workload unit is assigned an impact number representing the number of days that the expiration date of a computer system would be changed if the workload unit were to be added or removed from the system with all other workload units remaining the same. Each workload unit may be assigned a different number for each system in the environment. The inventive system and method simplify the task of combining multidimensional workload measures and incorporate the interaction with other workload units in the system by assessing the impact on both a donor and a recipient computer systems' expiration dates. Thus, the invention provides a more robust way to measure the effect of moving workload units between systems to result in a better allocation of work amongst computer systems in a processing environment.

Fig. 1

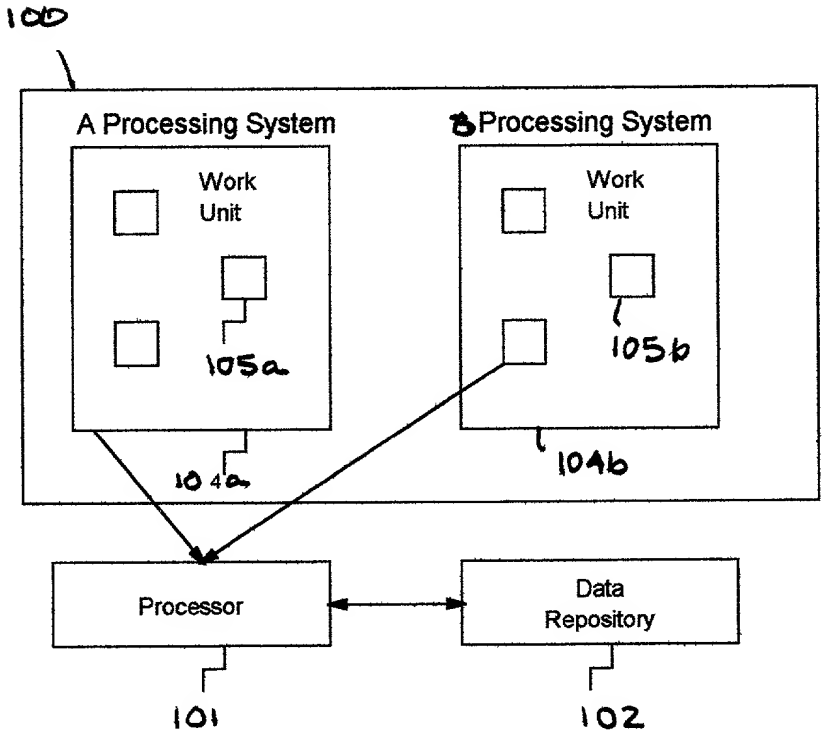

100
A Processing System
Processing System
Work Unit
Work Unit
105a
105b
104a
104b
Processor
Data Repository
101
102

Fig. 2.

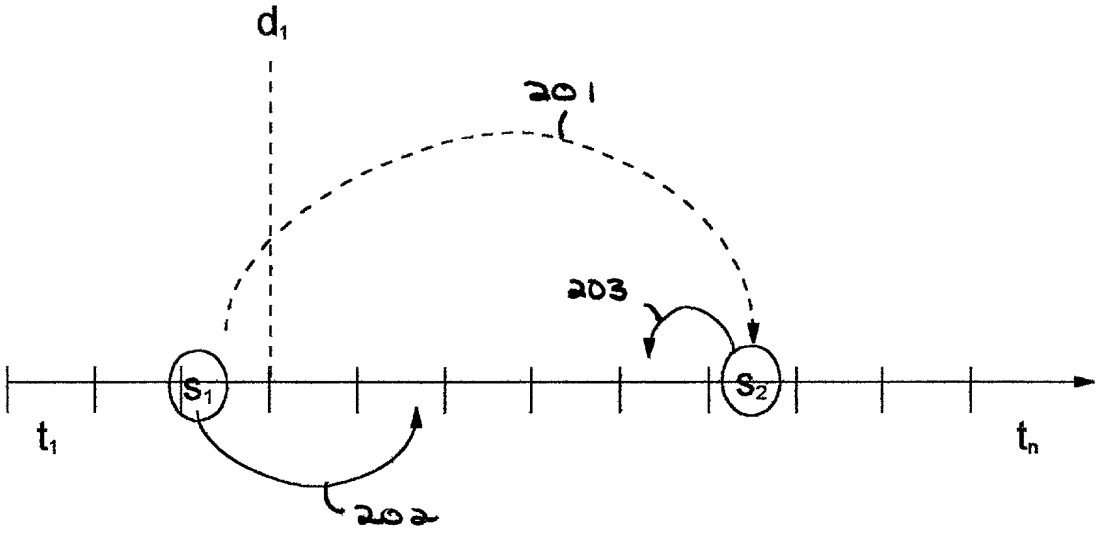
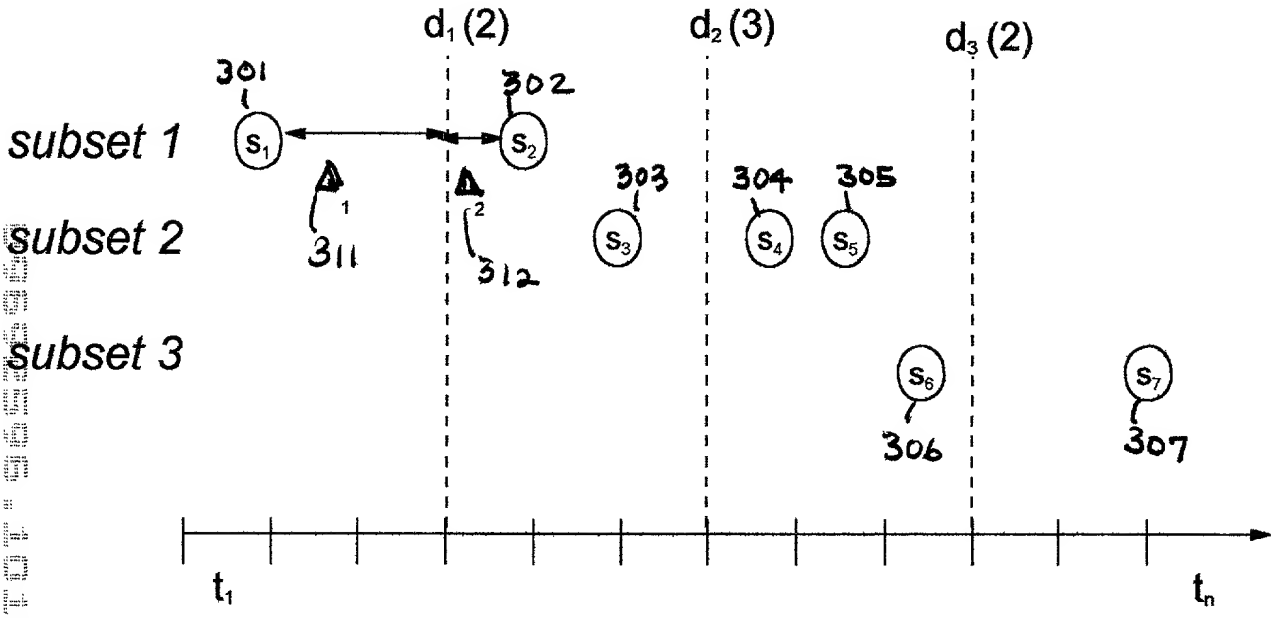


Fig.3


d1 (2)
d2 (3)
d3 (2)
301
302
303
304
305
306
307
subset 1
subset 2
subset 3
s1
s2
s3
s4
s5
s6
s7
Δ1
Δ2
311
312
t1
tn

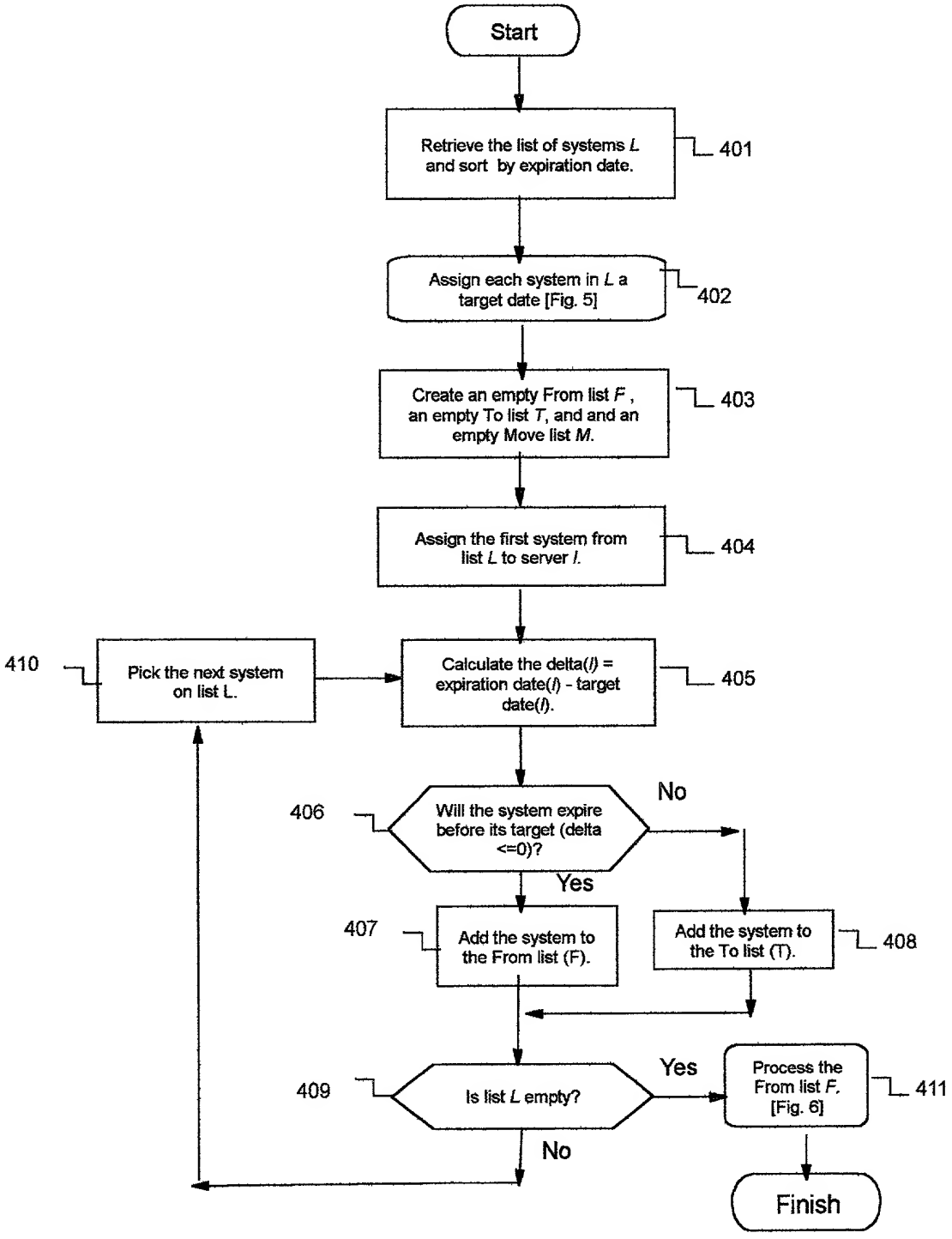

Start
Retrieve the list of systems L and sort by expiration date.
401
Assign each system in L a target date [Fig. 5]
402
Create an empty From list F, an empty To list T, and and an empty Move list M.
403
Assign the first system from list L to server I.
404
410
Pick the next system on list L.
Calculate the delta(I) = expiration date(I) - target date(I).
405
406
Will the system expire before its target (delta <=0)?
No
Yes
407
Add the system to the From list (F).
Add the system to the To list (T).
408
409
Is list L empty?
Yes
Process the From list F. [Fig. 6]
411
No
Finish

FIG. 4

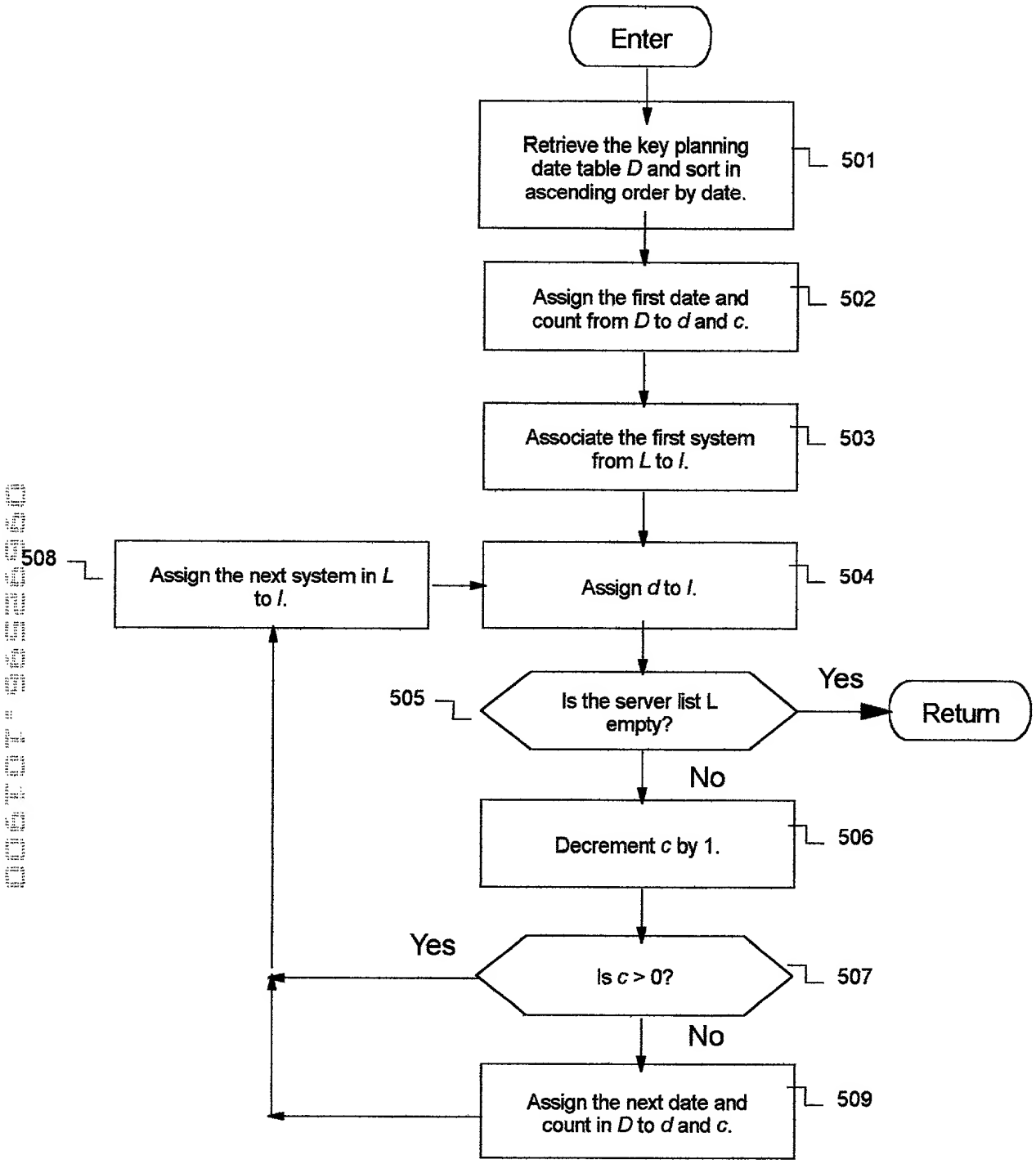

Enter
Retrieve the key planning date table D and sort in ascending order by date.
501
Assign the first date and count from D to d and c.
502
Associate the first system from L to l.
503
Assign d to l.
504
Assign the next system in L to l.
508
Is the server list L empty?
505
Yes
Return
No
Decrement c by 1.
506
Is c > 0?
507
Yes
No
Assign the next date and count in D to d and c.
509

FIG.5

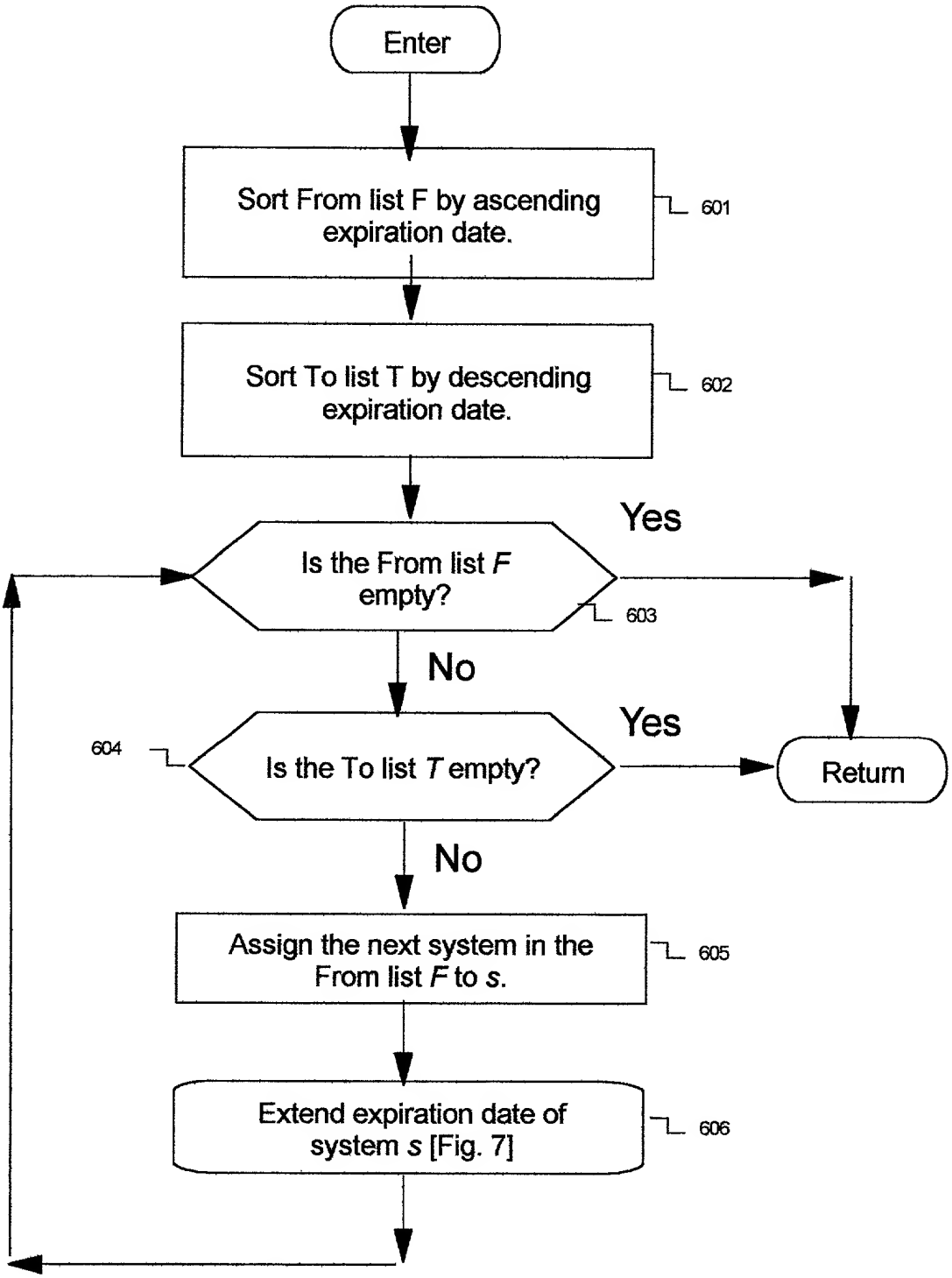

Enter
Sort From list F by ascending expiration date.
601
Sort To list T by descending expiration date.
602
Is the From list F empty?
603
Yes
No
604
Is the To list T empty?
Yes
Return
No
Assign the next system in the From list F to s.
605
Extend expiration date of system s [Fig. 7]
606

FIG. 6

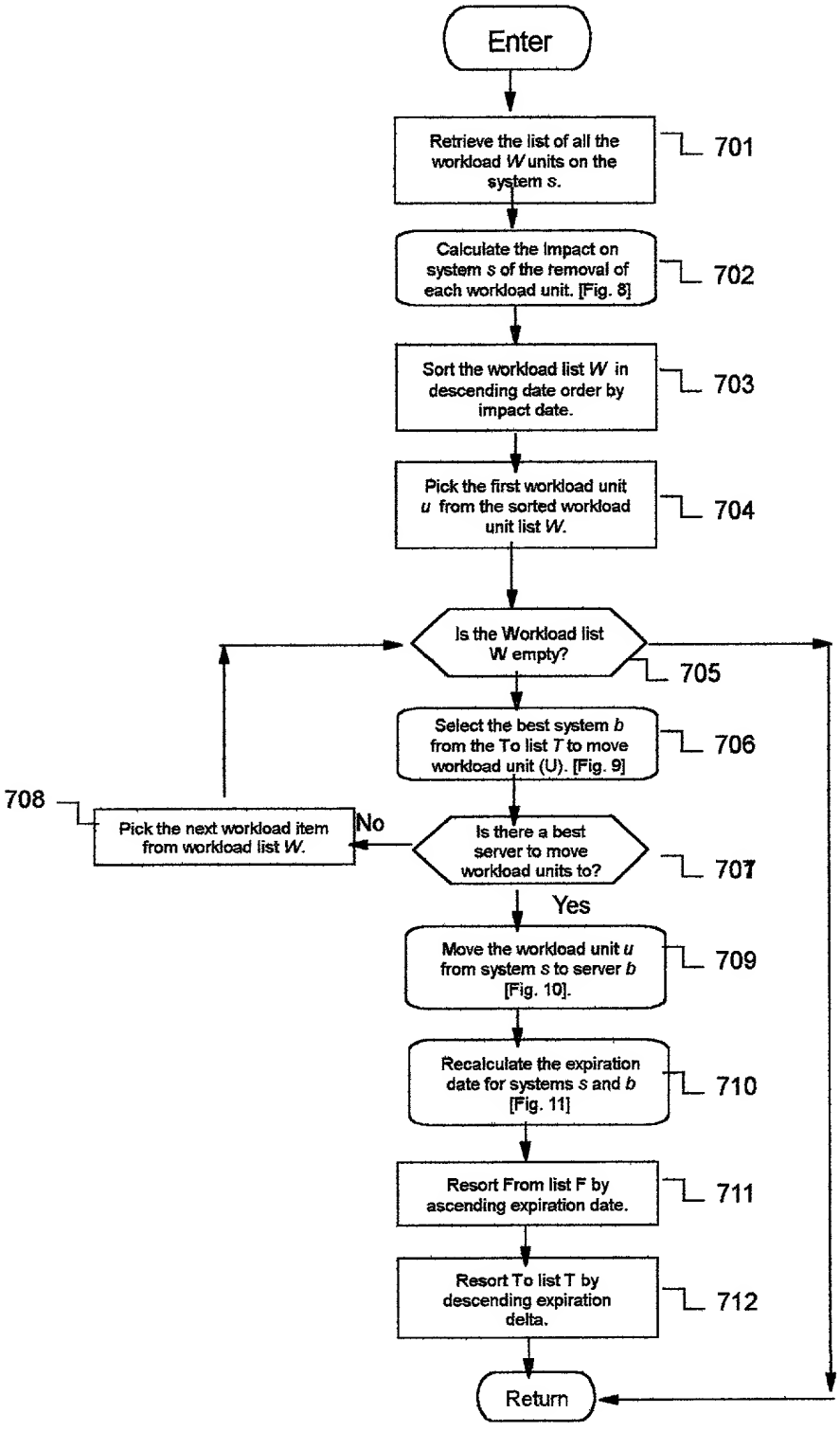

Enter
Retrieve the list of all the workload W units on the system s.
701
Calculate the Impact on system s of the removal of each workload unit. [Fig. 8]
702
Sort the workload list W in descending date order by impact date.
703
Pick the first workload unit u from the sorted workload unit list W.
704
Is the Workload list W empty?
705
Select the best system b from the To list T to move workload unit (U). [Fig. 9]
706
Is there a best server to move workload units to?
707
No
Pick the next workload item from workload list W.
708
Yes
Move the workload unit u from system s to server b [Fig. 10].
709
Recalculate the expiration date for systems s and b [Fig. 11]
710
Resort From list F by ascending expiration date.
711
Resort To list T by descending expiration delta.
712
Return

Fig. 7

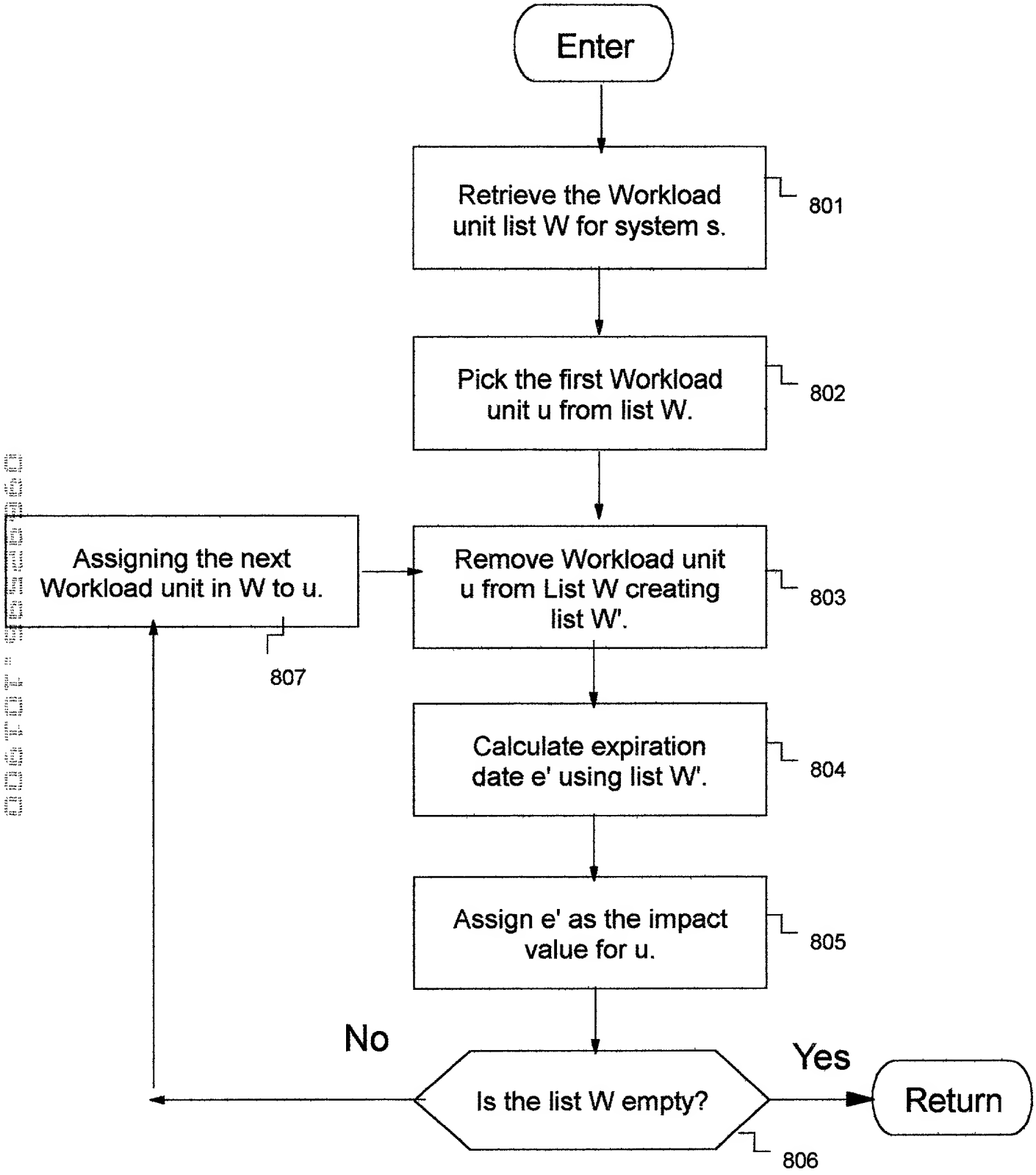

Enter
Retrieve the Workload unit list W for system s.
801
Pick the first Workload unit u from list W.
802
Remove Workload unit u from List W creating list W'.
803
Calculate expiration date e' using list W'.
804
Assign e' as the impact value for u.
805
Is the list W empty?
806
No
Yes
Return
Assigning the next Workload unit in W to u.
807

FIG. 8

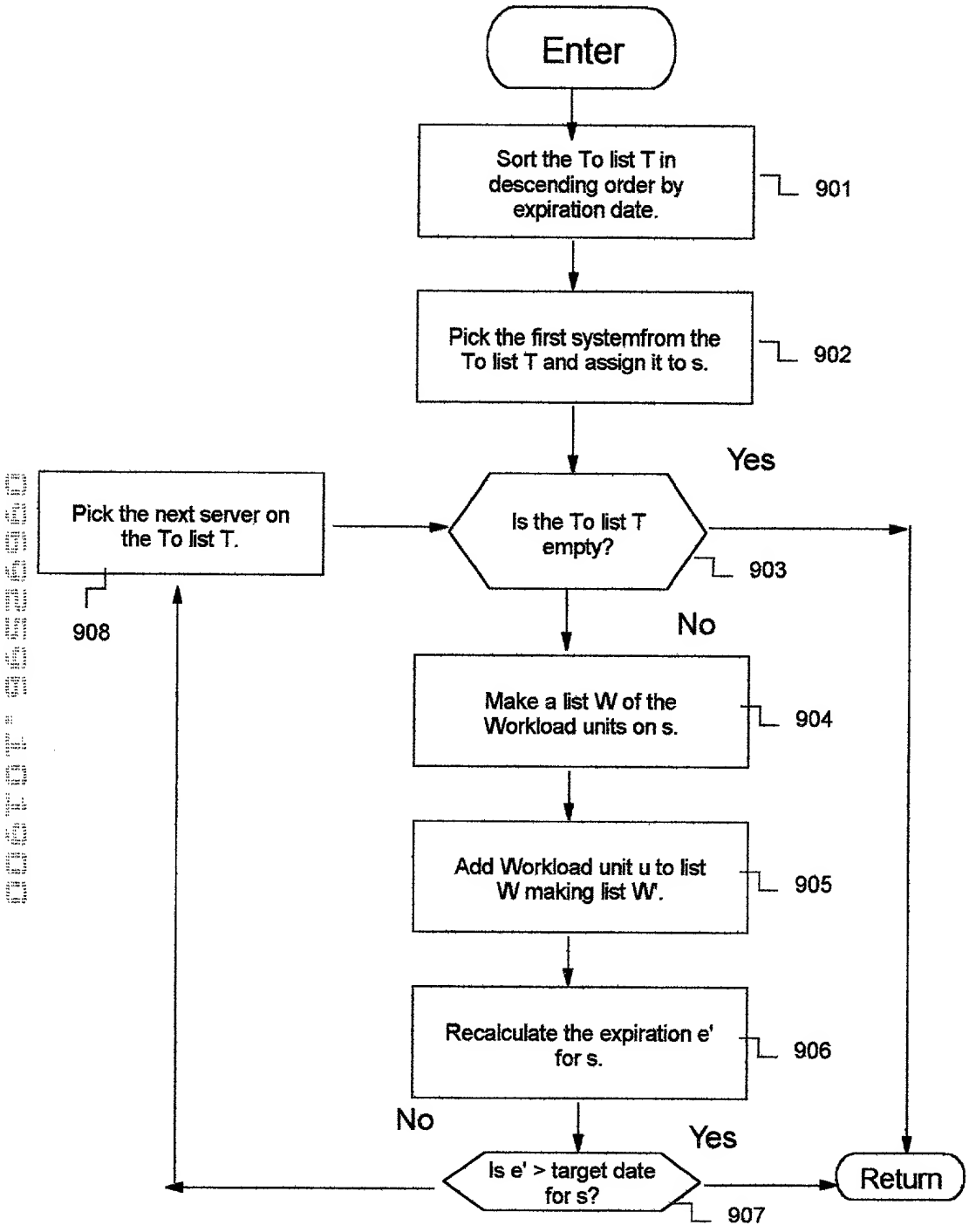

Enter
Sort the To list T in descending order by expiration date.
901
Pick the first systemfrom the To list T and assign it to s.
902
Yes
Pick the next server on the To list T.
Is the To list T empty?
903
908
No
Make a list W of the Workload units on s.
904
Add Workload unit u to list W making list W'.
905
Recalculate the expiration e' for s.
906
No
Yes
Is e' > target date for s?
907
Return

FIG. 9

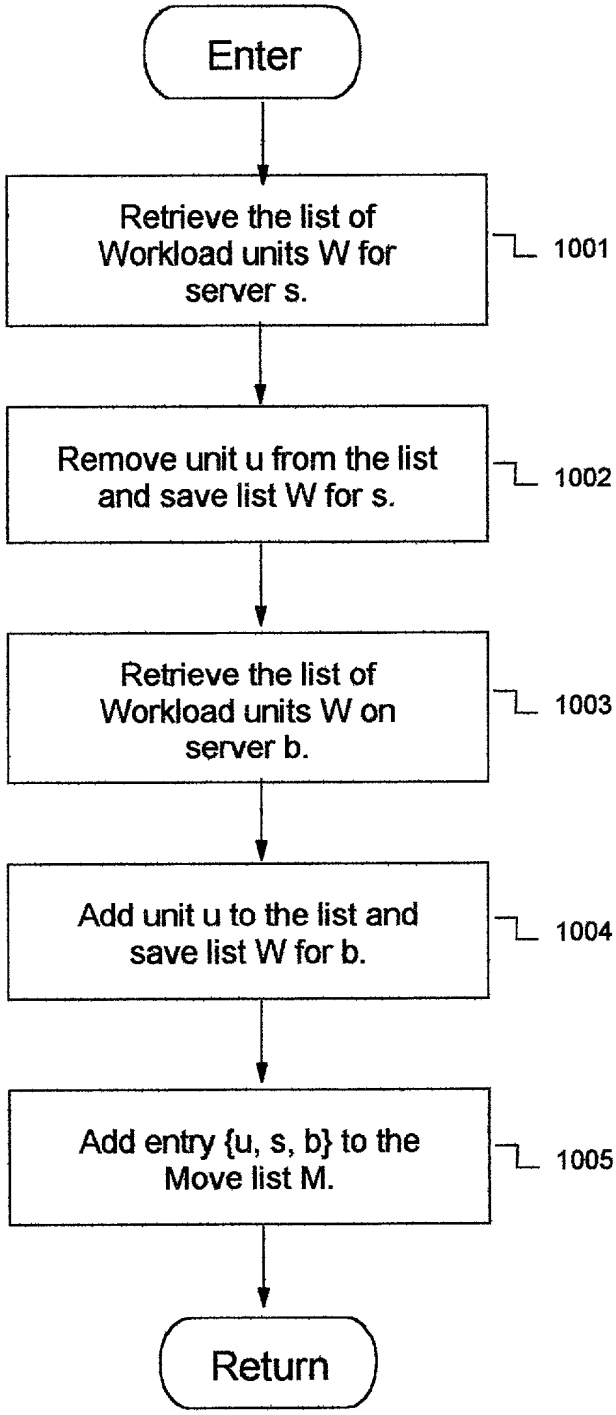

Enter
Retrieve the list of Workload units W for server s.
1001
Remove unit u from the list and save list W for s.
1002
Retrieve the list of Workload units W on server b.
1003
Add unit u to the list and save list W for b.
1004
Add entry {u, s, b} to the Move list M.
1005
Return

FIG. 10

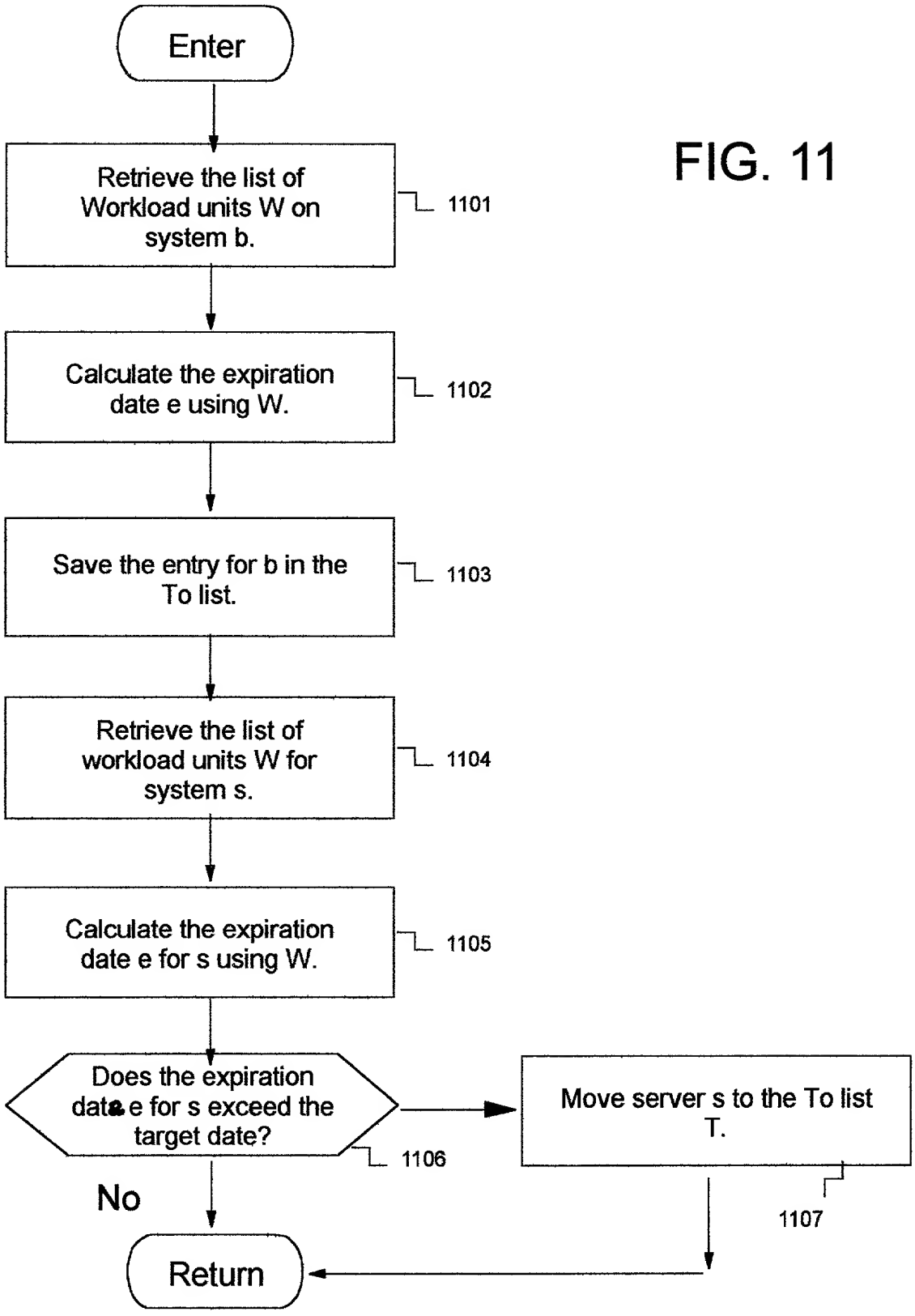

Enter
Retrieve the list of Workload units W on system b.
1101
Calculate the expiration date e using W.
1102
Save the entry for b in the To list.
1103
Retrieve the list of workload units W for system s.
1104
Calculate the expiration date e for s using W.
1105
Does the expiration date e for s exceed the target date?
1106
Move server s to the To list T.
1107
No
Return

FIG. 11

Docket No. YOR920000461

DECLARATION AND POWER OF ATTORNEY FOR PATENT APPLICATION

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name;

I believe I am an original, first and joint inventor of the subject matter which is claimed and for which a patent is sought on the invention entitled:

SYSTEM AND METHOD TO IMPROVE SERVICE IN A GROUP OF SERVERS

the specification of which (check one)

X is attached hereto.

____ filed on _____ as United States Application Number _____.

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the patentability of this application in accordance with Title 37, Code of Federal Regulations, Section 1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, §119(a)-(d) or §365(b) of any foreign application(s) for patent or inventor's certificate, or §365(a) of any PCT International application which designated at least one country other than the United States, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or PCT International application, having a filing date before that of the application on which priority is claimed:

Prior Foreign Application(s)			Priority Claimed
(Number)	(Country)	(Day/Month/Year Filed)	___ Yes ___ No

I hereby claim the benefit under 35 U.S.C. §119(e) of any United States provisional application(s) listed below.

(Application Number)	(Filing Date)

I hereby claim the benefit under 35 U.S.C. §120 of any United States Application(s), or §365(c) of any PCT International application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States, or PCT International application in the manner provided by the first paragraph of 35 U.S.C. §112, I acknowledge the duty to disclose information material to the patentability of this application as defined in 37 CFR §1.56 which occurred between the filing date of the prior application and the national or PCT international filing date of this application:

(Application Serial No.)	(Filing Date)	(Status) (patented, pending, abandoned)

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that willful false statements may jeopardize the validity of the application or any patent issued thereon.

POWER OF ATTORNEY: As a named inventor I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith (list name and registration number).

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DECLARATION AND POWER OF ATTORNEY FOR PATENT APPLICATION

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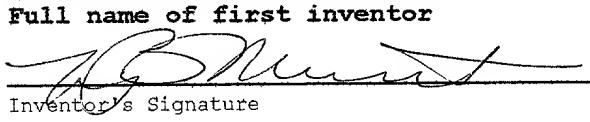
Full name of first inventor



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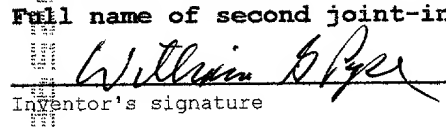

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